CLAIMS

1. A nuclear power plant thermal efficiency diagnostic system comprising:

a feed-and-condensate-water-flow-rate-setting-means for setting a flow rate of at least one of feedwater and condensate water in a nuclear power plant tentatively ;

a heat-exchange-on-heater-calculating-means for calculating heat exchange quantities of the feedwater and the condensate water on a heater arranged on a condensate and feedwater pipe of the nuclear power plant in accordance with the flow rate of at least the one of the feedwater and the condensate water, the flow rate being set by the feed-and-condensate-water-flow-rate-setting-means tentatively;

a HP-turbine-power-calculating-means for acquiring a calculated power value of a high pressure turbine of the nuclear power plant by assuming a dryness on an outlet of the high pressure turbine and performing a heat balance calculation using a heat exchange quantity of either of the feedwater and the condensate water acquired by the heat-exchange-on-heater-calculating-means;

a HP-turbine-power-correcting-means for making the HP-turbine-power-calculating-means correct the dryness on the outlet of the high pressure turbine to recalculate a power of the high pressure turbine when the calculated power value of the high pressure turbine is out of a threshold set on a basis of a reference power value of the high pressure turbine;

a HP-turbine-internal-efficiency-calculating-means for calculating an internal efficiency of the high pressure turbine based on the calculated power

value of the high pressure turbine;

a steam-condition-on-LP-turbine-inlet-calculating-means for setting a condition of a steam on an inlet of a low pressure turbine of the nuclear power plant;

a LP-turbine-power-calculating-means for acquiring a calculated power value of the low pressure turbine by assuming a reference expansion line of the low pressure turbine based on the condition of the steam on the inlet of the low pressure turbine and performing a heat balance calculation using a heat exchange quantity of either of the feedwater and the condensate water acquired by the heat-exchange-on-heater-calculating-means and the assumed reference expansion line of the low pressure turbine, the condition being set by the steam-condition-on-LP-turbine-inlet-calculating-means;

a LP-turbine-power-correcting-means for making the LP-turbine-power-calculating-means correct the reference expansion line of the low pressure turbine to recalculate a power of the low pressure turbine when the calculated power value of the low pressure turbine is out of a threshold set on a basis of a reference power value of the low pressure turbine;

a LP-turbine-internal-efficiency-calculating-means for calculating an internal efficiency of the low pressure turbine based on the calculated power value of the low pressure turbine; and

a performance-deteriorating-element-specifying-means for specifying an element which causes on deterioration of performance of the nuclear power plant based on the internal efficiency of the low pressure turbine calculated by the LP-turbine-internal-efficiency-calculating-means and the internal efficiency of the high pressure turbine calculated by the

HP-turbine-internal-efficiency-calculating-means.

2. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

wherein the HP-turbine-power-correcting-means is configured to use a measured power value of the high pressure turbine as the reference power value of the high pressure turbine and the LP-turbine-power-correcting-means is configured to use a measured power value of the low pressure turbine as the reference power value of the low pressure turbine.

3. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

further comprising a shaft torque sensor for measuring a shaft torque of at least one of the high pressure turbine and the low pressure turbine,

wherein the HP-turbine-power-correcting-means is configured to use a measured shaft torque value of the high pressure turbine acquired by the shaft torque sensor as the reference power value of the high pressure turbine and the LP-turbine-power-correcting-means is configured to use a measured shaft torque value of the low pressure turbine acquired by the shaft torque sensor as the reference power value of the low pressure turbine.

4. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

further comprising a plant-state-optimizing-means for determining whether the internal efficiency of the low pressure turbine, the internal

efficiency of the high pressure turbine, a calculated value of a flow rate of the feedwater and a calculated value of a flow rate of the condensate water are optimized based on the internal efficiency of the low pressure turbine calculated by the LP-turbine-internal-efficiency-calculating-means, the internal efficiency of the high pressure turbine calculated by the HP-turbine-internal-efficiency-calculating-means, the calculated value of the flow rate of the feedwater, the calculated value of the flow rate of the condensate water, a reference value of the internal efficiency of the low pressure turbine, a reference value of the internal efficiency of the high pressure turbine, a reference value of the flow rate of the feedwater and a reference value of the flow rate of the condensate water and making the feed-and-condensate-water-flow-rate-setting-means reset a flow rate of either of the feedwater and the condensate water tentatively in case of determining that an optimization is incomplete.

5. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

further comprising a plant-state-optimizing-means for determining whether the internal efficiency of the low pressure turbine, the internal efficiency of the high pressure turbine, a calculated value of a flow rate of the feedwater, a calculated value of a flow rate of the condensate water and a calculated value of a heat receiving quantity of steam at a nuclear reactor are optimized based on the internal efficiency of the low pressure turbine calculated by the LP-turbine-internal-efficiency-calculating-means, the internal efficiency of the high pressure turbine calculated by the HP-turbine-internal-efficiency-calculating-means, the calculated value of the

flow rate of the feedwater, the calculated value of the flow rate of the condensate water, the calculated value of the heat receiving quantity of the steam at the nuclear reactor, a reference value of the internal efficiency of the low pressure turbine, a reference value of the internal efficiency of the high pressure turbine, a reference value of the flow rate of the feedwater, a reference value of the flow rate of the condensate water and a reference value of the heat receiving quantity of the steam at the nuclear reactor and making the feed-and-condensate-water-flow-rate-setting-means reset a flow rate of either of the feedwater and the condensate water tentatively in case of determining that an optimization is incomplete.

6. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

further comprising a plant-state-optimizing-means for determining whether the internal efficiency of the low pressure turbine, the internal efficiency of the high pressure turbine, a calculated value of a flow rate of the feedwater, a calculated value of a flow rate of the condensate water and an internal efficiency of a turbine for driving a reactor feedwater pump are optimized based on the internal efficiency of the low pressure turbine calculated by the LP-turbine-internal-efficiency-calculating-means, the internal efficiency of the high pressure turbine calculated by the HP-turbine-internal-efficiency-calculating-means, the calculated value of the flow rate of the feedwater, the calculated value of the flow rate of the condensate water, the internal efficiency of the turbine for driving the reactor feedwater pump, a reference value of the internal efficiency of the low pressure turbine, a reference value of the internal efficiency of the high

pressure turbine, a reference value of the flow rate of the feedwater, a reference value of the flow rate of the condensate water and a reference value of the internal efficiency of the turbine for driving the reactor feedwater pump and making the feed-and-condensate-water-flow-rate-setting-means reset a flow rate of either of the feedwater and the condensate water tentatively in case of determining that an optimization is incomplete.

7. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

wherein the LP-turbine-power-calculating-means is configured to calculate the power of the low pressure turbine using a drain quantity caught by a drain catcher arranged in the low pressure turbine.

8. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

wherein the HP-turbine-power-calculating-means is configured to acquire the calculated power value of the high pressure turbine by assuming a reference expansion line of the high pressure turbine and performing the heat balance calculation using the heat exchange quantity of the either of the feedwater and the condensate water acquired by the heat-exchange-on-heater-calculating-means, the reference expansion line of the high pressure turbine and a drain quantity caught by a drain catcher arranged in the high pressure turbine.

9. A nuclear power plant thermal efficiency diagnostic system according to claim 1,

further comprising a plant-state-optimizing-means for performing an optimized calculation of a calculated value of the internal efficiency of the high pressure turbine calculated by the HP-turbine-internal-efficiency-calculating-means, a calculated value of the internal efficiency of the low pressure turbine calculated by the LP-turbine-internal-efficiency-calculating-means, a calculated value of a flow rate of the feedwater, a calculated value of a flow rate of the condensate water statistically using either of normal distribution and probability distribution obtained by integrating the normal distribution so as to minimize a deviation between each calculated value and a corresponding reference value.

10. A nuclear power plant thermal efficiency diagnostic method comprising steps of:

setting a flow rate of at least one of feedwater and condensate water in a nuclear power plant tentatively ;

calculating heat exchange quantities of the feedwater and the condensate water on a heater arranged on a condensate and feedwater pipe of the nuclear power plant in accordance with the flow rate of at least the one of the feedwater and the condensate water, the flow rate being set tentatively;

acquiring a calculated power value of a high pressure turbine of the nuclear power plant by assuming a dryness on an outlet of the high pressure turbine and performing a heat balance calculation using a acquired heat exchange quantity of either of the feedwater and the condensate water ;

correcting the dryness on the outlet of the high pressure turbine to

recalculate a power of the high pressure turbine when the calculated power value of the high pressure turbine is out of a threshold set on a basis of a reference power value of the high pressure turbine;

calculating an internal efficiency of the high pressure turbine based on the calculated power value of the high pressure turbine;

setting a condition of a steam on an inlet of a low pressure turbine of the nuclear power plant;

acquiring a calculated power value of the low pressure turbine by assuming a reference expansion line of the low pressure turbine based on the set condition of the steam on the inlet of the low pressure turbine and performing a heat balance calculation using an acquired heat exchange quantity of either of the feedwater and the condensate water and the assumed reference expansion line of the low pressure turbine;

correcting the reference expansion line of the low pressure turbine to recalculate a power of the low pressure turbine when the calculated power value of the low pressure turbine is out of a threshold set on a basis of a reference power value of the low pressure turbine;

calculating an internal efficiency of the low pressure turbine based on the calculated power value of the low pressure turbine; and

specifying an element which causes on deterioration of performance of the nuclear power plant based on the internal efficiency of the low pressure turbine and the internal efficiency of the high pressure turbine.

11. A nuclear power plant thermal efficiency diagnostic program allowing a computer to function as:

a feed-and-condensate-water-flow-rate-setting-means for setting a

flow rate of at least one of feedwater and condensate water in a nuclear power plant tentatively ;

a heat-exchange-on-heater-calculating-means for calculating heat exchange quantities of the feedwater and the condensate water on a heater arranged on a condensate and feedwater pipe of the nuclear power plant in accordance with the flow rate of at least the one of the feedwater and the condensate water, the flow rate being set by the feed-and-condensate-water-flow-rate-setting-means tentatively;

a HP-turbine-power-calculating-means for acquiring a calculated power value of a high pressure turbine of the nuclear power plant by assuming a dryness on an outlet of the high pressure turbine and performing a heat balance calculation using a heat exchange quantity of either of the feedwater and the condensate water acquired by the heat-exchange-on-heater-calculating-means;

a HP-turbine-power-correcting-means for making the HP-turbine-power-calculating-means correct the dryness on the outlet of the high pressure turbine to recalculate a power of the high pressure turbine when the calculated power value of the high pressure turbine is out of a threshold set on a basis of a reference power value of the high pressure turbine;

a HP-turbine-internal-efficiency-calculating-means for calculating an internal efficiency of the high pressure turbine based on the calculated power value of the high pressure turbine;

a steam-condition-on-LP-turbine-inlet-calculating-means for setting a condition of a steam on an inlet of a low pressure turbine of the nuclear power plant;

a LP-turbine-power-calculating-means for acquiring a calculated power value of the low pressure turbine by assuming a reference expansion line of the low pressure turbine based on the condition of the steam on the inlet of the low pressure turbine and performing a heat balance calculation using a heat exchange quantity of either of the feedwater and the condensate water acquired by the heat-exchange-on-heater-calculating-means and the assumed reference expansion line of the low pressure turbine, the condition being set by the steam-condition-on-LP-turbine-inlet-calculating-means;

a LP-turbine-power-correcting-means for making the LP-turbine-power-calculating-means correct the reference expansion line of the low pressure turbine to recalculate a power of the low pressure turbine when the calculated power value of the low pressure turbine is out of a threshold set on a basis of a reference power value of the low pressure turbine;

a LP-turbine-internal-efficiency-calculating-means for calculating an internal efficiency of the low pressure turbine based on the calculated power value of the low pressure turbine; and

a performance-deteriorating-element-specifying-means for specifying an element which causes on deterioration of performance of the nuclear power plant based on the internal efficiency of the low pressure turbine calculated by the LP-turbine-internal-efficiency-calculating-means and the internal efficiency of the high pressure turbine calculated by the HP-turbine-internal-efficiency-calculating-means.